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(71) Applicant:
Federal-Mogul Bradford Limited
Manchester, M22 5TN (GB)

(72) Inventors:
- Gazzard, Simon Thomas
Skipton, North Yorkshire BD23 1QR (GB)
- Philby, Jonathan David
Ilkley, West Yorkshire LS29 7LL (GB)
- Barnes, Simon
Rugby, Warwickshire CV22 6LJ (GB)

(74) Representative:
Gibson, George Kevin et al
T&N Limited Patent and Trade Mark Department,
Manchester International Office Centre,
Styal Road
Manchester M22 5TN (GB)

(54) Aluminium alloy containing silicon for use as pistons in automobiles

(57) An improved aluminium - silicon alloy for use in the manufacture of pistons is disclosed. The improved alloy is of the following composition in which the component elements are

10.5 to 13.5 silicon
2.0 to less than 4.0 copper
0.8 to 1.5 magnesium
0.5 to 2.0 nickel
0.3 to 0.9 cobalt
at least 20 ppm phosphorous
and either

(i) 0.05 to 0.2 titanium; or
(ii)at least one of the following

up to 0.2 zirconium
up to 0.2 vanadium;
in either case with the balance Aluminium and unavoidable impurities.

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Description

[0001] The present invention relates to a aluminium-silicon alloy. The alloy has use in the manufacture of pistons, in particular for pistons for use in internal combustion engines.

[0002] A satisfactory piston material must meet many differing requirements. In use, pistons are exposed to both static and dynamic stresses, while operating in bulk temperatures from sub-zero to up to 400°C. These stresses will also differ in different regions of the piston; for example a combustion bowl in a piston will be subject to different thermal and mechanical stresses than piston pin bosses. The piston must also have low thermal expansion, and possess good bearing characteristics with marginal lubrication over the noted range of temperatures. Also, the piston material must lend itself to being formed into a piston, for example by casting with subsequent working.

[0003] Known casting alloys for piston manufacture include those disclosed in Japanese Patent Application J01108339-A. Among the alloys disclosed therein is an aluminium based alloy including silicon from 9 to 12 percent, copper from 0.5 to 2.5 percent, magnesium from 0.8 to 2.0 percent, cobalt from 0.5 to 3 percent, nickel from 1 to 3 percent, iron from 0.3 to 1.0 percent, manganese from 0.1 to 1.0 percent and titanium from 0.01 to 0.15 percent with the balance being aluminium and unavoidable impurities. This alloy is said to provide high strength from 150 to 250 °C.

[0004] Another alloy is disclosed in DE 44 04 420 which may have application as an alloy for use in the manufacture of pistons for an automotive vehicle. The alloy comprises from 8.0 to 10.9 percent silicon, from 0.8 to 2.0 percent magnesium, from 4.0 to 5.9 percent copper, from 1.0 to 3.0 percent nickel, from 0.2 to 0.4 percent manganese, less than 0.5 percent iron and at least one element from the group including antimony, zirconium, titanium, strontium, cobalt, chrome and vanadium whereby at least one element is present in an amount greater than 0.8 percent and the sum of the elements in this group is no more than 0.8 percent, with the balance of the alloy being aluminium and unavoidable impurities.

[0005] The present invention has as an advantage that it provides good strength over the range of temperatures in which a piston made from the alloy operates.

[0006] The alloy of the present invention is selected from a group of aluminium alloys with each alloy component element being present in weight percent as follows:

10.5 to 13.5 silicon
2.0 to less than 4.0 copper
0.8 to 1.5 magnesium
0.5 to 2.0 nickel
0.3 to 0.9 cobalt
at least 20 ppm phosphorous
and either

(i) 0.05 to 0.2 titanium; or
(ii) at least one of the following

up to 0.2 zirconium
up to 0.2 vanadium;
in either case with the balance Aluminium and unavoidable impurities.

[0007] Preferably Zinc, Lead and Tin may also be present up to 0.15 weight percent. More preferably, the total amount of Lead and Tin may not exceed 0.15 weight percent.

[0008] The Copper allows age hardening of the alloy. An increase the amount of Copper beyond the limit stated reduces the high temperature fatigue strength of the alloy due to the generation of larger Copper-Nickel rich intermetallic crystals. An increase in the Copper level can also lead to shrinkage porosity problems in larger castings.

[0009] The Magnesium is present to contribute to the strength of the alloy. However, increasing the amount of Magnesium will lead to larger intermetallics in the as cast condition, but after aging these will be removed. The Magnesium is added at a level where it provides good strengthening after aging through the formation of Mg_2Si. Higher Magnesium levels lead to greater oxidation losses during the casting process, and thus a greater tendency for the cast metal to contain oxide defects.

[0010] The Nickel contributes to the high temperature strength of the alloy by the formation of thermally stable intermetallic crystals. However, exceeding the limits stated will reduce the high temperature fatigue strength of the alloy due to the precipitation of coarse intermetallic crystals. This tendancy is made worse by the low cooling rates associated with the casting of large pistons.

[0011] The Cobalt content is chosen to allow the formation of a large number of small intermetallics. This is believed to improve the mechanical properties of the alloy at 350°C. In addition, the presence of the Cobalt in the Aluminium alloy at the levels stated is believed to reduce the diffusivity of the Copper in Aluminium, thereby slowing the overaging mechanism of the alloy. This has particular importance when considering the operation of a piston pin boss operating at around 200°C. However, the presence of the Cobalt is believed also to lead to an increase in fatigue strength of the alloy at 350°C. This is of particular importance when considering the operation of a combustion bowl of a piston which is typically subject to such temperatures.

[0012] The Titanium or Zirconium and/or Vanadium are each present as a grain refining addition.

[0013] Preferably, the alloy may optionally include at least one of the following

up to 0.5 iron
up to 0.25 manganese

up to 0.05 chrome, and

up to 15 ppm each of calcium, sodium, strontium and lithium.

[0014] The present invention will now be described, by way of example only, with reference to the following Illustrative Examples.

Example 1

[0015] The use of a specific alloy composition in the manufacture of forged pistons has proven to be particularly advantageous. The metal alloy compositions of this alloy with the component elements being indicated in weight percent are as follows:

10.5 to 13.5 silicon
2.0 to less than 4.0 copper
0.8 to 1.5 magnesium
0.5 to 2.0 nickel
to 0.9 cobalt
0.05 to 0.2 titanium
at least 20 ppm phosphorous
with the balance Aluminium and unavoidable impurities.

Example 2

[0016] Another alloy within the scope of the present invention also found to have utility in the manufacture of pistons has the following composition with the component elements being indicated in weight percent as follows:

10.5 to 13.5 silicon
2.0 to less than 4.0 copper
0.8 to 1.5 magnesium
0.5 to 2.0 nickel
0.3 to 0.9 cobalt
at least 20 ppm phosphorous; and
at least one of the following
up to 0.2 zirconium
up to 0.2 vanadium;
with the balance Aluminum and unavoidable impurities.

Example 3

[0017] Another alloy within the scope of the present invention found to have utilty in the manufacture of pistons has the following composition with the component elements being indicated in weight percent as follows:

10.5 to 11.5 silicon
2.5 to 3.5 copper
0.8 to 1.5 magnesium
0.5 to 1.5 nickel
0.3 to 0.7 cobalt
up to 0.20 titanium
up to 0.2 zirconium
up to 0.2 vanadium
up to 0.50 iron
up to 0.25 manganese
up to 0.05 chrome
up to 0.15 zinc
up to 0.15 lead
up to 0.15 tin; the total of lead and tin not to exceed 0.15
at least 20 ppm phosphorous
up to 15 ppm each of calcium, sodium, strontium and lithium
with the balance Aluminium and unavoidable impurities

[0018] The alloys of the present invention, in addition to their use in the manufacture of forged pistons, may be used in the manufacture of gravity die cast pistons.

Claims

1. An aluminium alloy in which the component elements are present in weight percent as follows:

   10.5 to 13.5 silicon
   2.0 to less than 4.0 copper
   0.8 to 1.5 magnesium
   0.5 to 2.0 nickel
   0.3 to 0.9 cobalt
   at least 20 ppm phosphorous
   and either

   (i) 0.05 to 0.2 titanium; or
   (ii) at least one of the following

   up to 0.2 zirconium
   up to 0.2 vanadium;
   in either case with the balance Aluminium and unavoidable impurities.

2. An alloy according to claim 1, characterised in that Zinc, Lead and Tin may also be present up to 0.15 wt% as unavoidable impurities.

3. An alloy according to claim 2, characterised in that the total amount of Lead and Tin does not exceed 0.15 wt%.

4. An alloy according to any of claims 1 to 3, characterised in that the alloy may optionally include at least one of the following

   up to 0.5 iron
   up to 0.25 manganese
   up to 0.05 chrome, and
   up to 15 ppm each of calcium, sodium, strontium and lithium.

5. A piston manufactured from an alloy according to any previous claim.

6. A piston according to claim 5, characterised in that the piston is manufactured by forging.

7. A piston according to claim 5, characterised in that the piston is manufactured by gravity die casting.

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EUROPEAN SEARCH REPORT

Application Number
EP 98 12 3801

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A,D	PATENT ABSTRACTS OF JAPAN vol. 013, no. 331 (C-622), 25 July 1989 & JP 01 108339 A (TOYOTA MOTOR CORP), 25 April 1989 * abstract * ---	1-7	C22C21/02
A	WO 91 02100 A (COMALCO LTD) 21 February 1991 ---	1-7	
A	PATENT ABSTRACTS OF JAPAN vol. 096, no. 011, 29 November 1996 & JP 08 176768 A (NISSAN MOTOR CO LTD), 9 July 1996 * abstract * ---	1-7	
A,D	DE 44 04 420 A (ALCAN GMBH) 17 August 1995 ---	1-7	
A	US 4 648 918 A (ASANO KAZUHIKO ET AL) 10 March 1987 -----	1-7	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			C22C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	22 March 1999	Badcock, G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 98 12 3801

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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22-03-1999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9102100 A	21-02-1991	AU 639253 B	22-07-1993
		AU 6156490 A	11-03-1991
		EP 0486552 A	27-05-1992
		AT 132912 T	15-01-1996
		CA 2064807 A	10-02-1991
		DE 69024808 D	22-02-1996
		DE 69024808 T	30-05-1996
		US 5484492 A	16-01-1996
DE 4404420 A	17-08-1995	NONE	
US 4648918 A	10-03-1987	JP 1433172 C	07-04-1988
		JP 60184667 A	20-09-1985
		JP 62002623 B	21-01-1987
		JP 60197838 A	07-10-1985
		JP 62038420 B	18-08-1987
		JP 1399620 C	07-09-1987
		JP 60221559 A	06-11-1985
		JP 61024461 B	11-06-1986

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 97/00088

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5057274 A	15-10-91	JP 61291941 A	22-12-86
		US 4934442 A	19-06-90
EP 0141501 A	15-05-85	JP 1018980 B	10-04-89
		JP 1537103 C	21-12-89
		JP 60197836 A	07-10-85
		JP 1668826 C	29-05-92
		JP 3032403 B	13-05-91
		JP 60196219 A	04-10-85
		JP 60197837 A	07-10-85
		JP 60056057 A	01-04-85
		CA 1239811 A	02-08-88
		CH 665223 A	29-04-88
		DE 3469187 A	10-03-88
		US 4737206 A	12-04-88

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 97/00088

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 014, no. 513 (C-0777), 9 November 1990 & JP 02 213442 A (SUMITOMO LIGHT METAL IND LTD), 24 August 1990, see abstract	1-20
A	PATENT ABSTRACTS OF JAPAN vol. 014, no. 080 (C-0689), 15 February 1990 & JP 01 298131 A (KOBE STEEL LTD), 1 December 1989, see Table 2 of patent document see abstract	1-20
A	PATENT ABSTRACTS OF JAPAN vol. 011, no. 176 (C-426), 5 June 1987 & JP 62 001839 A (SKY ALUM CO LTD), 7 January 1987, see Tables in patent document see abstract	1-20

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